R E P O R T R E S U M E S

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SCIENTIFIC LITERACY IN THE SIXTIES.

BY- KOELSCHE, CHARLES L. MORGAN, ASHLEY G.
GEORGIA UNIV., ATHENS

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DESCRIPTORS- *LITERACY, *SCIENTIFIC LITERACY, *SCIENTIFIC PRINCIPLES, CONCEPT FORMATION, GENERAL EDUCATION, READING, PHYSICAL SCIENCE STUDY COMMITTEE, CHEMICAL BOND APPROACH, CHEMICAL EDUCATIONAL MATERIALS STUDY, BIOLOGICAL SCIENCES CURRICULUM STUDY, ATHENS

RESEARCH WAS CONDUCTED TO ESTABLISH THE DEGREE OF SCIENTIFIC KNOWLEDGE THAT IS REQUIRED TO UNDERSTAND SCIENCE ARTICLES IN CURRENT NEWSPAPERS AND MAGAZINES. ALL ARTICLES ABOUT SCIENCE OR REQUIRING SCIENCE FOR INTERPRETATION WERE COLLECTED FOR A 6-MONTH PERIOD FROM NINE MAGAZINES AND 22 NEWSPAPERS. TERMS WERE CATEGORIZED AND RELATED TO THE SCIENTIFIC PRINCIPLE WITH WHICH THEY RELATED. ARTICLES ON THE LIFE SCIENCES YIELDED 76 PRINCIPLES, PHYSICS 76, AND CHEMISTRY 17. THE TERMS AND PRINCIPLES IDENTIFIED ARE INCLUDED IN THE REPORT. INFORMATION ABOUT THE NEWS ITEMS ANALYZED IS PROVIDED. INCLUDED ARE (1) NEWSPAPER SOURCES OF THE ARTICLES, (2) FREQUENCY OF ARTICLES IN NEWSPAPERS FROM VARIOUS GEOGRAPHIC REGIONS, AND (3) SCIENCE ARTICLE LOCATION IN THE NEWSPAPER FORMAT. A DISCUSSION OF SCIENTIFIC LITERACY AND OF THE IMPLICATIONS OF THE STUDY FOR SCIENCE EDUCATION ARE INCLUDED. (RS)

Scientific Literacy In The Sixties

Doctors Refuse to Ask Chloromycetin Control

State Committee Decides New Federal Drug Law Will Militate Against Use

...committee of publi... physicians Tuesday ... against recommend... legislation to control the use of ... antibiotic Chloro... known by practic...

...ittee w... Senate ... deep-sea ... contend... for the 60 to 80... aplastic anemia ... annually in Cali... reported t... physici...

...aplastic anemia, a condition which kills half of its victims.

In deciding against recommending legislative ... the ... heart...

...ventures related to ... therapeutic mis... phenicol (Chlo... "Should ... contin...

...have a prominent part ... scientific observations in this remote region of two-mile-thick ice this winter, which is South Polar ...

...ations will be carried out ... Bureau sci...

...AS R. HENRY ... Manager Alliance ... Wealth...

Chicago Tribune SUNDAY, FEBRUARY 24, 1963

New Surgery Told for Cancer of Esophagus

Japanese Expert Uses Stapling Machine to Transplant Colon Section to Throat

BY HARRY NELSON, Times Medical Edit

A Japanese surgeon's in... for the surgeon to b... genuity and skill have been... has gotten all the e... combined in a new surgical... When the... ment for ... of the...

...SUNDAY, ... 1962

16-D The Atlanta Journal and CONSTITUTION

Icy Weather Aker, Antarctica, Told

...AS PART OF ... by Dr. F. W. ... bureau will analyze ... and solar radiation in the area ... the Ross Sea. The work will be ...

...carried out large... air and will ...utics and include photographic investigation aid "this of the types of ice and seasonal is back ...ditions are expected to contribute ...ovide knowledge about the heat ...ter- ...actions of this region and the role ...t."

TURN ON VENUS PROBE DEVICES AFTER 'REST'

Washington, Nov. 8 (UPI) — A signal flashed 14,600,000 miles into space turned on four interplanetary ... the ... ruments aboard ...pacecraft today ...en shut down ...cause of a ...wer supply.

...ded from ... last Aug. 27, ...stance of 20,900 miles on ...ec. 14. Instruments on board ... are expected to provide new information about the mysterious planet.

Since then, the 447 ... craft has ...

Section 1A - 13

Navy Prepares 2d Stage of Search for Common Cold Vaccine

...Naval ...cruits last December will be ...dministered to other recruits ...ade or res...

The first evaluation of the success of the hyperimmune gamma globulin will be possi... A... 15, he added, will be ...

...Cross blood center staff of Madison, Wis.

Gamma globulin antibodies are formed in the blood of individuals who have had an infectious illness. The antibodies help the patient to overcome ...ness and protect him from ... it again in the im...

Capt. Miller

If the results are positive after the inoculations are given to the incoming recruits, researchers feel that development of an effective vaccine against respiratory disease is a definite possibility.

Respiratory diseases include the common cold, pharyngitis and bronchitis, and bronchial pneumonia.

...ices are a ...ember

CHICAGO DAILY TRIBUNE:

14 The Atlanta Journal Monday, November 19, 1962

Transfusions Hold Peril, Surgeon Says

CHICAGO, Nov. 19 (... — Blood ... ransfusions, a veteran ... aid Monday, may ... me cases rat... Dr. Phi...

Boy Gets Bitten by Biology Bug

Home Hums with Hamsters

BY JEAN KOTULAK

No member of his family is too surprised when Bruce Hummond wanders thru his Skokie home with one hand full of sunflower seeds and the other full of worms.

The choice morsels are food for some of his current pets, which range from chameleons to salamanders, and which ... found all over the ... at 9053 ... the ...

—TUES., MAR. 5, 1963 Los Angeles Times 2★

...t on All Infants for ...lson's Disease Urged

...iment Caused by Inability to Dispose of ...opper in Food Leads to Mental Trouble

Phoenix, Sat., April 6 1963

...s Promise ...r Conversion

CHICAGO DAILY TRIBUNE: MONDAY, NOVEMBER 26, 1962

...Mariner Signals Cover Record Distance

...us Arrival

...ample, is life possible on this ...lanet, spelled ...

...lasting and ...

★THE ... Wed., Ja...

...ariner ...ioneer ...he sun.

...Telstar Finds Russ Blast Radiation Band

The great Atlanta Journal Monday, December 10, 1962

...e some sort of mechanism at ...clear the radia...

...been expected. Brown told a meeting of the American Physical Society.

...clearing center of the gap between the belts.

The Oct. 28 nuclear blast nearly filled the slot again, and ... was set in again ... before.

Charles L. Koelsche and Ashley G. Morgan, Jr.

...ife on Venus?—We May Find Out This ...Week

...erda Now

The satellite also is measuring two of the least known aspects of the sun — ultra violet and X-ray radiation, which are believed to play an important part in plant and animal life.

But NASA scientists consider the unusually long life of the satellite as one of its greatest achievements. This means that

...is the closest approach ever to the mystery planet.

spacecraft's mission, after ...month flight in space, is to ...ate the shroud of clouds ... Venus and report whether ...net is capable of harbor...

...JET spacecraft launched ... 1961, passed within 62,... of Venus. But its radio ...

...the two ban... ...s the Semi-Conductor Research Section, said...

...had gone silent and the Soviet ... probe was a scientific failure.

The U.S. craft still is on course, traveling at 22,000 miles per hour. If its instruments do not falter in the next few days, it will supply some of the answers about Venus, that man has sought for centuries.

Mariner 2, which left the earth at Cape Canaveral, Fla., Aug. 27 aboard an Atlas-Agena B rocket, ...dis... ...beca... up ... was ...

...ady has broken all previous spacecraft records for long-distance radio communications.

The previous record, 22.5 million miles, was set by America's Pioneer 5 spaceprobe on June 26, 1960. Mariner beat that mark Nov. 25 and has been going strong ever since.

IT HAS transmitted more information about interplanetary ...

space beyond the moon than had ever been gleaned before. For the first time, in response to radio commands from earth, a spacecraft has changed pace and course in flight.

It has penetrated far deeper into space than any other craft whose attitude was controlled by stabilizing jets. These jets, ac... vated by ...

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION

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SCIENTIFIC LITERACY IN THE SIXTIES

by

Charles L. Koelsche

Professor of Science Education

University of Georgia

and

Ashley G. Morgan, Jr.

Chairman, Department of Science Education

University of Southern Mississippi

Printing Department
University of Georgia
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PREFACE

Developments in the fields of science during the past decade are having considerable influence upon the environment and many aspects of our social, economic, and personal problems. In fact, one is hard pressed to find some facet of our daily contacts and experiences that have not in some way been affected by scientific discoveries and technology.

This situation stimulated the authors to raise several questions about the significance of science education and what citizens in a science-oriented social order needed to know to become independent and logical thinkers when hearing and/or reading about anything involving science and its applications. In other words, what does a person need to know in order to be scientifically literate in the sixties?

A partial answer to this question can be derived from an analysis of materials presented for the "consumer" through the medias of mass communication. Daily newspapers and magazines published periodically were selected for study by us in hope that we could determine some of the basic scientific words and understandings essential to interpreting printed materials dealing with the various aspects of science. Persons working on science curriculum revision and science teachers may find the vocabulary and principles identified in this study helpful when considering topics for inclusion in the several science courses offered to students in their schools.

Sincere thanks are due the companies who participated in this project - their publications are listed in Appendixes A and B; to Virginia Williams for the meticulous job done in proofreading and typing for off-set printing; and to Emmaline Henriksen, an advanced graduate student in the Reading Clinic at the University of Georgia, for determining the reading comprehension level of the science articles.

CLK
AGM

Athens, Georgia
September, 1964

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INTRODUCTION

What does it mean to be scientifically literate? How can the level of scientific literacy be raised? Why is it important that all teachers and intelligent adults be scientifically literate in today's world? These and similar questions were posed recently to some leading science educators and distinguished scientists. A few of the more significant responses compiled by Robert H. Carleton and reported in the April, 1963, issue of the Journal of the National Education Association follow.

Dr. John S. Richardson, Professor of Education, Ohio State University, believes that scientific literacy requires an awareness of the separate, identifiable entities in the universe - matter, energy, and life - and of the essential relationships among the three. The scientifically literate person thus must be able to read and to discuss scientific information found in common literature and to interpret common scientific phenomena with facility and confidence. He must also be able to interrelate and to differentiate between science and applied science.

Dr. Hugh Odishaw, Executive Director, Space Science Board, National Academy of Sciences, indicates that scientific literacy can be defined as a comfortable familiarity with the development, methodology, achievements, and problems of the principal scientific disciplines.

Dr. Howard A. Meyerhoff, Chairman, Department of Geology, University of Pennsylvania, feels that scientific literacy calls for familiarity with scientific methods and for sufficient knowledge in the several fields of science to understand reports of new discoveries and advances.

Dr. Paul DeH. Hurd, Professor of Education, Stanford University, believes that a scientifically literate person has a precise understanding of some of the key concepts, laws, and theories of science. He can relate these concepts, laws, and theories in a logical and coherent manner and can

appreciate their significance.

Dr. M. H. Trytten, Director, Office of Scientific Personnel, National Academy of Sciences, indicates that any discussion of scientific literacy should differentiate between knowledge about science and understanding of science. The person who seriously wishes to understand science, therefore, should look for materials that bear upon science's nature and functioning. He should seek, for example, to understand the basic principles and unifying concepts of science in their simplest operations. It is better to have a thorough understanding of Newton's laws in physics or of the role of the cell in biology than to know the galaxy of space vehicles.

In an editorial that appeared recently in The Science Teacher, Dr. E. G. Sherburne, Jr. stated that every citizen needs to have some understanding and appreciation of science in order to fulfill his role as a decision-making member of a democratic society. The society in which the decisions are made is composed largely of laymen, and they must be the guardians of decisions, no matter how complex. As Thomas Jefferson expressed it, "There is no safe depository of the ultimate power of society but in the people themselves." We must, therefore, demand a scientifically literate public to participate in the democratic process. Such a public should be familiar with some of the big concepts, with some idea of scientific methodology, and its various approaches to the discovery of new knowledge.

A compilation of recent information on science curriculum revision in the high schools of America discloses that a gradual shift in emphasis is taking place. More time is being devoted to a study of fundamental science principles and processes and less time spent on technology and learning of definitions and facts. Accompanying the change in content is a shift from lecture-demonstration techniques to inquiry and discovery through laboratory work and research activities.

This change has been motivated in part by nationally-financed projects, such as the Physical Science Study Committee, Chemical Bond Approach, Chemical Education Materials Study, and Biological Sciences Curriculum Study. Similar projects are underway in the fields of earth science, junior high school science, and several separate projects on elementary school science. Other significant factors which contributed to this transposition are the knowledge that any given group of scientific phenomena is subject to change during each ensuing 15-year cycle, and the total accumulation of scientific knowledge is almost doubling every 10 years.

What does a person need to know in order to be scientifically literate in this aerospace age? Do the new science courses that were developed by the curriculum study groups furnish basic science subject matter essential for scientific literacy? Can a science education program in the public schools provide young people and adults with the knowledge essential for scientific literacy? If so, what science topics should be included in the several required courses? To answer these and other related questions, investigations in the field of scientific literacy must supply data upon which pertinent generalizations can be made.

Unfortunately, a large segment of the adult population never took a basic course in biology, chemistry, or physics. What knowledge they possess has been acquired through reading daily newspapers, magazines, and books, or hearing about it through the mass communication media - television and/or radio. If they have children in school, some carry-over from this source may be significant.

During the past 20 years, a number of doctoral-level studies were concerned with basic principles of science. These principles were isolated from many sources and their significance to an understanding of science was confirmed by juries of experts selected from the several areas of science and

from leading science educators. These lists of principles have been revised and kept up to date as research in science produced additional pertinent information.

This analysis of scientific information needed by persons living in the sixties to interpret and understand printed materials appearing in newspapers and magazines made extensive use of these lists in identifying kinds of science subject matter and experiences in science that should be available to students in the schools of this Nation. Furthermore, the findings reported herewith should prove helpful in answering at least in part some of the questions associated with scientific literacy.

The procedures used for securing data pertinent to the problem involved nine steps. They were:

1. Six-month subscriptions were taken to 22 daily newspapers located in strategic sections of the United States. Similar subscriptions were taken to nine of the most widely-circulated magazines.

2. Upon receipt of the newspapers and magazines, an inspection of every page was made and any article that dealt with science in any form whatsoever was clipped, dated, location in publication noted, and identified with the name of the newspaper or magazine.

3. A group of folders were labeled with the name of each newspaper and magazine and became the filing place for every news item or article clipped.

4. Records were kept on the folder covers that showed the number of clippings filed each day for the newspapers or each week or month for the magazines.

5. Every news item was then read meticulously and any phrase or word requiring a knowledge of science to understand it was underlined.

6. These underlined segments were copied and categorized according to

the science area with which they were associated.

7. An analysis was made of the word or phrase to identify the related science principle or concept needed by the reader in order to comprehend its meaning.

8. Lists of science words and principles thus identified were compiled.

9. The grade level of reading comprehension essential to an understanding of the newspaper or magazine articles was determined by a specialist in the Reading Clinic at the University of Georgia.

FINDINGS

The major objectives of this project were to determine the scientific information needed by people in order to interpret and understand science articles they read in newspapers and magazines, and to provide science curriculum study groups with information that could serve as a guide to desirable course content in science for general education.

To obtain current science articles for analysis, 22 daily newspapers and nine magazines were reviewed systematically during the interim of November 1, 1962 to May 1, 1963. A total of 2,999 articles were thus identified. Lists of the newspapers and magazines and the cities in which they were published are compiled in the appendix. Those selected had the largest circulation in their respective regions.

Information regarding the frequency of science articles in newspapers is compiled in Table I.

According to Table I, a total of 2,883 articles requiring some knowledge and understanding of science appeared in the 22 newspapers during the six-month period. Moreover, the month of December, 1962, had 33.6 per cent of the articles; whereas, November of that year was not far behind with 28.4 per cent. Together, these two months yielded 1,788 or 62.0 per cent of the script.

TABLE I. NUMBER OF SCIENCE ARTICLES APPEARING EACH MONTH IN THE 22 NEWSPAPERS

Newspaper	1962		1963				
	November	December	January	February	March	April	Totals
A	43	75	19	15	23	24	199
B	36	62	13	10	16	8	145
C	35	31	24	21	15	9	135
D	8	11	2	3	2	1	27
E	54	55	20	22	16	15	182
F	37	89	19	12	13	15	185
G	13	12	2	2	1	1	31
H	37	62	16	26	15	14	170
I	40	43	7	8	10	11	119
J	105	40	23	21	28	17	234
K	39	38	10	8	5	11	111
L	17	39	10	5	9	6	86
M	68	71	15	11	13	15	193
N	8		(On strike)		6	2	16
O	44	61	18	17	13	15	168
P	51	78	18	11	16	18	192
Q	13	27	6	5	6	4	61
R	31	58	14	10	21	17	151
S	26	47	14	6	15	5	113
T	35	9	8	8	14	4	78
U	79	61	24	13	18	18	213
V	(Four months only)		20	9	20	25	74
Totals	819	969	302	243	295	255	2,883

Only 243 or 8.4 per cent of the science news items appeared in February, 1963. The median number of articles published per month during the six-month period was 480 with a minimum-maximum of 243 and 969 respectively. One of the subscriptions was for four months, and in another instance, publication of the paper was interrupted for a three-month period by a strike.

There was considerable variation in the number of science-oriented news items in the several papers. Three from the Pacific Region yielded 625 articles for an average of 208 each; three from the Mountain Region, 367 with an average of 122; and three from the Southeast Region, 309 for an average of 103. Five from the North Central Region yielded 795 articles for an average of 159 each;

four from the South Central Region, 502 with an average of 125; and four from the North East, 285 for an average of 71. In this latter group of newspapers, the one having a four-month subscription and the one afflicted with a three-month strike were present. Newspapers A, J, and P were in the Pacific Region; U was in the North Central area; and M, South Central.

Science articles appearing in these newspapers came from a variety of sources. Table II shows the principal ones.

TABLE II. SOURCES OF ARTICLES APPEARING IN THE NEWSPAPERS

News-paper	Source of News Items								
	AP	UPI	LATS	WPS	NYTS	NANA	PRIVATE	OTHERS	TOTAL
A	61	31	14	14	0	3	75	1	199
B	39	25	0	0	14	0	67	0	145
C	41	39	0	0	3	15	37	0	135
D	13	5	0	0	0	0	8	1	27
E	31	25	0	0	0	0	125	1	182
F	70	19	1	0	10	1	79	5	185
G	17	0	0	0	0	0	14	0	31
H	58	0	0	0	6	8	59	39	170
I	56	0	0	0	15	1	35	12	119
J	27	21	0	18	0	0	151	17	234
K	25	17	0	0	4	0	64	1	111
L	75	4	0	0	0	0	7	0	86
M	95	0	0	0	0	0	77	21	193
N	3	2	0	0	0	0	11	0	16
O	0	39	0	0	0	13	113	3	168
P	75	0	3	3	0	13	94	4	192
Q	49	3	0	0	0	0	9	0	61
R	44	12	24	14	17	0	35	5	151
S	24	21	2	4	12	0	45	5	113
T	31	0	0	0	11	0	36	0	78
U	88	0	0	0	0	1	116	8	213
V	11	10	4	0	0	0	47	2	74
Totals	933	273	48	53	92	55	1304	125	2883

AP - Associated Press
UPI - United Press International
LATS - Los Angeles Times Service
Others - Included Science Service, Copley News Service, Reuters, etc.
WPS - Washington Post Service
NYTS - New York Times Service
NANA - North American Newspaper Alliance
PRIVATE - Scientists, technicians, and science editors

Examination of these data discloses that all of the 22 newspapers obtain science-oriented news through private sources. Of the 2,883 articles, 1,304 or 45.2 per cent were acquired in this manner. Second in importance was the Associated Press Syndicate that accounted for 32.4 per cent of the script. The United Press International contributed 9.5 per cent. These three sources together were responsible for 87.0 per cent of all science articles appearing in these papers during the six-month period.

The distribution of science articles according to the section in and page on which they were found is given in Table III.

TABLE III. DISTRIBUTION OF SCIENCE ARTICLES THROUGHOUT THE FORMAT OF THE 22 NEWSPAPERS

News-paper	First Section - Pages										Totals
	1-3	4-6	7-9	10-12	13-15	16-18	19-21	22-24	25-27	28-up	
A	17	5	20	16	16	18	13	6	5	0	116
B	28	17	10	4	6	5	1	2	1	1	75
C	25	11	6	6	10	7	9	6	6	2	88
D	5	3	3	2	4	0	1	0	1	2	21
E	35	18	17	7	8	5	2	4	0	0	96
F	23	11	18	17	10	17	10	11	7	2	126
G	10	5	7	1	3	2	0	0	1	0	29
H	22	18	21	20	9	20	9	5	7	1	132
I	22	15	7	16	7	4	5	4	2	1	83
J	49	12	7	6	6	10	3	12	8	0	113
K	22	15	7	9	3	3	3	2	0	0	64
L	22	11	16	4	1	0	0	0	0	0	54
M	20	19	20	10	6	8	5	5	9	1	103
N	0	1	2	2	1	1	1	1	0	0	9
O	32	15	14	9	6	9	8	4	4	0	101
P	18	23	23	23	17	17	16	7	6	4	154
Q	23	5	9	7	5	0	1	1	1	0	52
R	67	28	10	12	8	6	2	1	1	0	135
S	24	7	12	8	4	4	1	0	0	0	60
T	11	15	6	1	9	6	1	1	3	0	53
U	80	38	16	11	9	2	9	5	4	0	174
V	30	13	9	1	3	1	1	0	0	0	58
Totals	585	305	260	192	151	145	101	77	66	14	1896

TABLE III Continued

Newspaper	Second Section - Pages										Totals
	1-3	4-6	7-9	10-12	13-15	16-18	19-21	22-24	25-27	28-up	
A	4	22	11	16	10	2	4	0	0	1	70
B	4	4	4	7	0	0	1	0	0	0	20
C	7	9	7	5	4	1	2	1	0	1	37
D	3	2	0	0	0	0	0	0	0	0	5
E	7	4	2	1	0	0	1	0	0	0	15
F	6	4	2	4	1	7	6	0	1	4	35
G	0	0	0	0	0	0	0	0	0	0	0
H	7	2	2	1	0	0	0	0	0	0	12
I	3	8	6	3	0	2	0	0	0	0	22
J	26	18	2	1	0	0	0	0	0	0	47
K	12	5	4	4	2	2	0	0	0	0	29
L	8	5	3	2	0	0	0	0	0	0	18
M	6	9	1	1	1	1	1	1	1	0	22
N	1	0	0	0	0	0	1	0	0	1	3
O	9	5	4	6	3	4	6	1	2	1	41
P	6	2	1	9	2	1	0	0	0	0	21
Q	0	0	0	0	1	0	2	0	0	0	3
R	0	2	1	0	1	0	0	0	0	0	4
S	14	4	4	2	1	0	0	0	0	0	25
T	2	6	3	0	0	2	0	1	0	0	14
U	3	5	4	2	2	1	1	1	2	0	21
V	2	0	1	0	0	0	0	0	0	0	3
Totals	130	116	62	64	28	23	25	5	6	8	467
In miscellaneous sections											520

An analysis of data in Table III reveals that of the 1,896 articles appearing in the first section, 585 or 30.9 per cent were found on the first three pages. A further breakdown of this group divulges that 304 news items were located on the front pages. Roughly three-fifths of these articles appeared on the first nine pages.

Moreover, considerable variation in location of news items dealing with scientific phenomena was noted in different newspapers. Approximately one-half of all such items found in papers J, Q, R, U, and V were on pages 1 to 3; whereas, these types of articles were quite evenly distributed throughout the first 20 pages of section one in papers A, D, F, H, and P. A decided drop in

frequency was observable as the end of the section was approached.

The data for section two discloses almost the same findings as presented for section one.

The remaining 520 articles were found in several miscellaneous places in the various newspapers.

Table IV shows the categorization of news items according to the science area involved.

TABLE IV. CATEGORIZATION OF ARTICLES ACCORDING TO THE PRINCIPAL SCIENCE AREA INVOLVED

Newspaper	Biology	Chemistry	Physics	Geology	General	Totals
A	103	12	68	7	9	199
B	72	5	61	4	3	145
C	79	5	42	3	6	135
D	9	0	17	0	1	27
E	66	9	95	3	9	182
F	69	11	80	13	12	185
G	7	1	20	1	2	31
H	62	20	62	6	20	170
I	50	6	56	2	5	119
J	105	10	103	4	12	234
K	44	6	46	6	9	111
L	28	4	46	2	6	86
M	82	6	90	6	9	193
N	10	0	5	1	0	16
O	85	3	68	7	5	168
P	89	7	73	16	7	192
Q	23	2	29	4	3	61
R	66	2	72	6	5	151
S	50	0	56	4	3	113
T	32	1	39	4	2	78
U	102	7	88	5	11	213
V	32	2	36	2	2	74
Totals	1265	119	1252	106	141	2883

The compiled data in this table indicate that 2,517 or 87.3 per cent of the science articles were almost divided equally between the fields of biology and physics; 4.1 per cent were related to chemistry; 3.7 per cent, geology; and

4.9 per cent, general science. Astronomical and meteorological items were tabulated under physics. Articles involving several science areas were categorized as "general."

Of the seven newspapers having 182 or more science articles, only J maintained an equal distribution between biology and physics; whereas, paper A had 51.8 per cent of the news items related to biology and only 34.2 per cent dealt with physics. Science news items in papers P and U were also oriented toward biology, but papers E and F yielded physics articles in more abundance. The volume of chemistry-related articles was the heaviest in newspaper H and the most geology-related articles appeared in P.

Six-month subscriptions were also taken to nine widely-read magazines. There were 116 science-oriented articles clipped from these. A tabulation of the number of articles according to publication and science area is shown in Table V.

TABLE V. CLASSIFICATION OF MAGAZINE ARTICLES ACCORDING TO THE PRINCIPAL SCIENCE AREA INVOLVED

Magazine	Biology	Chemistry	Physics	Geology	General	Totals
A	1	0	0	0	0	1
B	7	0	0	0	0	7
C	0	0	0	0	0	0
D	7	1	3	2	1	14
E	1	0	0	0	1	2
F	1	0	0	0	0	1
G	15	0	3	0	0	18
H	4	0	1	2	1	8
I	32	2	26	5	0	65
Totals	68	3	33	9	3	116

An examination of data in Table 5 divulges that more than half of the science articles appeared in magazine I, while one-fourth of the script was divided between D and G, and roughly one-eighth was split between B and H. No science articles were found in magazine C during the subscription period.

Moreover, 68 or 58.7 per cent of the articles dealt with some phase of

the biological sciences, 33 or 28.4 per cent with physics and related fields, and only 15 or 12.9 per cent with the combined areas of chemistry, geology, and general science. Three of the magazines had articles dealing only with biology; whereas, D was the only one having script in each of the five science areas.

An analysis of a random sample of the newspaper and magazine articles by a specialist in the Reading Clinic at the University of Georgia revealed that the median grade level of readibility was eleven with a minimum-maximum of four and sixteen respectively.

Summary. Six-month subscriptions were taken to 22 newspapers having the largest circulation in their geographical region of the United States and to nine of the most widely-read magazines published in this country. The subscription period was from November 1, 1962 to May 1, 1963. There were 2,999 science-oriented news items clipped from the 31 publications during this interim. A breakdown of these articles revealed that 2,883 came from newspapers located in the following regions: Pacific - 3 - 625; Mountain - 3 - 367; North Central - 5 - 795; South Central - 4 - 502; Southeast - 3 - 309; and Northeast - 4 - 285; the remaining 116 science articles were observed in the magazines.

November and December, 1962, yielded 1,788 or 62.0 per cent of the newspaper articles; whereas, February, 1963, with 243 or 8.3 per cent was the lowest month. The median number of articles published per month was 480 with a minimum-maximum of 243 and 969, respectively. The Pacific Region newspapers averaged 208 each month; the North Central Region, 159; South Central, 125; Mountain, 122; Southeast, 103; and Northeast, 71.

The most prevalent source of science-oriented articles for the newspapers was private releases. Of the 2,883 articles, 1,304 or 45.5 per cent were acquired in this manner. The Associated Press accounted for about one-third, and the United Press International, roughly one-tenth.

Science news items were found distributed throughout the papers, but roughly two-thirds of them appeared in section one with about three-fifths of them printed on the first nine pages. Three-hundred and four or 10.5 per cent of the items were located on the front pages so one might say they constituted headline copy.

Approximately seven-eighths of the science articles were divided about equally between the fields of biology and physics. Astronomical and meteorological items were tabulated under physics. The remaining articles were scattered almost equally in the other science areas.

News items in the field of biological science made up roughly three-fifths of the 116 science articles located in the nine magazines. Physics was the next most prevalent science area in which articles were categorized. Three magazines had articles in the field of biology only, and only one had articles in all of the five science areas listed - biology, chemistry, physics, geology, and general science. Furthermore, Time Magazine yielded 65 or 56.0 per cent of the 116 science articles, and one of the magazines had no science articles during the six-month interim.

The median level of reading comprehension needed in order to interpret and understand material in the science articles was found to be on the eleventh grade level with extremes of four and sixteen.

PRINCIPLES AND VOCABULARY

In selecting the principles and vocabulary needed to interpret and understand scientific information appearing in printed news items, the authors analyzed each article and located every word and/or phrase that dealt with science in any way whatsoever. Because both investigators had strong academic backgrounds in the various fields of science and had extensive teaching experience on the elementary, secondary, and college levels, it was felt that their

identification of scientific information and subsequent correlation with the proper science principles and vocabulary was done objectively and is, therefore, reliable and valid. No other criteria entered into the compilation of the lists of 175 principles and 693 vocabulary words.

Except in the field of chemistry, no attempt was made to categorize the words according to science areas, but it seemed feasible to tabulate principles by their related fields even though some overlapping and dual classification is possible.

GENERAL VOCABULARY NEEDED FOR INTERPRETING AND UNDERSTANDING SCIENCE-ORIENTED ARTICLES

abdomen
ablation
achromatic
aconite
acromegaly

actinomyces
actinomycete
adenosine tri-
  phosphate (ATP)
adenovirus
adipose tissue

adrenal cortex
aeration
aerodynamics
agammaglobulinemia
agate

agglutinin
algae
allergy
alloy
alkaline cyanide

alkaline phosphatase
alkaloid
alternating current
alternator
amino acid

ammonia
ammonium dihydrogen
  phosphate

amphibian
anabolic
anaphylactic

anatomy
anesthetic
aneurysm
angina pectoris
annular eclipse

anode
anthropoid
anthropologist
anthropometric
antibiotic

antibody
anticoagulant
antiepileptic
antigen
antimony

antiparticle
antisenescence
antiseptic
anus
aorta

aphelion
apogee
archaeology
arginine
argon

arsenic
asteroid
astronaut
astronomy
atheromatous plaque

atherosclerosis
atmosphere (pressure)
atom
atomic energy
atomic particle

atropine
auricle
Auriga
aurora
autoimmunity

bacterium
barite
barium
barium titanate
barometric pressure

basophil
battery
bauxite
benzene hexachloride
benzaldehyde

beryl
beryllium
beta ray

bev
bevatron

biochemistry
biocurrent
bioelectronics
biologist
biota

boric acid
breeder reactor
British thermal unit (BTU)
bromine
bronchitis

cadmium sulfide
calcite
calcium complex
calcium hydrogen phosphate
calorie

cancer
Capella
carbonate
carbohydrate
carbon

carbon dioxide
carbon monoxide
carbonic acid
carcinogen
cardiac

cardiovascular
carrier signal
catalyst
cathode
cathode ray tube

cell (Bio. & Phys.)(Chem.)
cellulose acetate
center of gravity
centigrade
centimeter

central nervous system
centrifuge
cepheid variable
cerebellum
cerebrum

cerium (144)
cesium
cesium nitrate

chain reaction
chemical

chemical element
chemically inert
chemotherapy
chitin
chlorine

chlorinated hydrocarbons
chlorophyll
cholesterol
chromite
chromium

chromosome
cirrhosis
cislunar
cloud seeding
coagulation

cobalt
coelacanth
coenzyme
coincidence counter
coleoptera

colitis
comet
concave (lens)
constellation
contraceptive

convection
convex (lens)
copper (64)
copper sulfate
cornea

corona
coronary
cortin
cortisone
cosmic ray

cretaceous
cretin
cryobiology
cryoelectron microscope
cryotherapy

crystal
cumulus cloud

curie
cybernetics
cycles/second

cyst
cystine
cystinuria
cytology
cytoplasm

dacron
dehydration
dendrochronology
density
dermatology

de(s)oxyribonucleic acid (DNA)
detergent
deuterium
devonian (period)
diabetic

dialysis
dieldrin
dimethylsulfoxide
dinosaur
diode

dipole
direct current
dolomite
dwarf star
dynamo effect

ecology
elastomer
electricity
electric field
electric lens

electrocardiogram
electrode
electroencephalograph
electrojet
electrolytic

electromagnetic wave
electron
electronic
electron microscope
electron volt

electrophoresis
electroretinograph
electrosome
electrostatic
emboli (air)

embryologist
emphysema
encephalitis
endocrine
energy

enterococcus
entomologist
enzyme
epidemiological
epinephrine

equatorial
ergot
esophagus
estrogen
ethyl bromide

eugenicist
evaporate
evolution (Biol. - Phys.)

Fahrenheit
fatty acid
femur
fermentation
ferridoxin

ferric chloride
fetus
fibrillating
fission
fissure

florigen
fluorescent
fluorides
fluospar
folic acid

frequency
friction
fuel cell
fungi imperfecti
fungus

fusion

galaxy
gamma (5 gamma magnetic field)
gamma globulin
gamma radiation
garnet

gastritis
geiger counter
gene
generic name
genetic

genitourinary
geochronology
geodetic
geopaleontology
geophysical

gland (endocrine)
glomerulonephritis
glycerine
goiter
gold

gonad
gonadotropic (harmone)
gonococcus
gossamer
gram

gram-negative (bacteria)
graphite
gravity
gyroscope

hafnium carbide
helium
hemoglobin
hemorrhage
heredity

herpes simplex
herpetology
histamine
histone
homeostasis

homo sapiens
hormone
hybrid
hydrocarbon
hydrocephalus

hydrochloric acid
hydrofluoric acid
hydrogen
hydrogen cyanide
hydrogen peroxide

hydrology
hyperbaric
hyperon
hyperplasia
hyperventilation

hypothalamus
hypothermia
hypothesis

immunity
implode
inclination (52 degrees)
incus
infrared

infrared spectrum
insulin
interferon
interplanetary (dust)
interstellar (gas-dust)

intrauterine
iodine
ion
ionosphere
iridium

iron
iso-lucine
isotope

joule

kalanchoe plant
kilo
krypton

larva
larynx
laser
lava
lead hydrogen chloride

lead sulfide

lethal dose 50 (LD-50)
leucocyte
lichen
light year

lipid
liter
lithium
lucine
lunar

lupus erythematosis
luteolin
lymphocyte
lysergic acid
lysergic acid amide

lysimeter
lysine

macromolecule
magnesium
magnesium ammonium phosphate
magnetic equator
magnetic field

magnetic lens
magnetohydrodynamic
magnetometer
magnetosphere
malignant

malleus
mammoth
manganese
Mars
maser

mass spectrometer
mastodon
medullary mitochondria
magacycle
menopause

mercury (Mercury)
meson
metabolism
metahydroxybenzoic acid
metamorphosis

metastasis
meteor

meteoroid
meteorology
methane

methionine
methyl testosterone
mica
micrometeoroids
micron

micro-organism
microscope
microsecond
microwave
milky way

milli-ampere
millimeter
mineral (Biol. - Geol.)
missile
mital valve

modulate
molecule
molybdenum
momentum
mongolism

moraine
motor neuron
muscovite
mutation
myelin

myoglobin

nanosecond
Neanderthal (man)
nebula
necrosis
neoplasm

nephritis
neptunium
nerve
neurohormone
neurokinase

neurokinin
neuron
neurosurgeon
neutrino
neutron

niobium
nitrogen
nitrogen dioxide
nitrogen oxide
nitroglycerine

nitroprusside
nova
nucleating agent
nucleic acid
nucleoprotein

nucleus (cell-atomic)

opthalmology
optic nerve
orbit
organella
organic

orthoptera
orthotics
osmium (187)
osmosis
ossify

osteoporosis
otosclerosis
ovum
oxidation
oxidative phosphorylation

oxygen
oxygenated
ozone

paleontology
palynology
pancreas
panspermia
parabolic

paradiaminoazobenzene
parametric
paraplegic
parthenogenesis
patheogenetical

pathological
pathologist
penicillin
peptic
pericyte

perigee
perihelion
perturbation
petroglyph
phagocyte

pharmaceutical
pharmacognosy
phenacetin
phenylalanine
phenylketonuria

phororhacid
phosphor
phosphoric acid
phosphorus
photoelectric

photomicrograph
photomultiplier tube
photon
photosphere
photosynthesis

physicist
physiology
pico
piezoelectric
pitchblend

pituitary
placenta
planet
plasma (Biol. - Phys.)
platinum

pleistocene
plexiglas
pliocene
plutonium (238)
polarized light

polyethylene
polymer
polymorphic
polyoma virus
polyunsaturated fat

positron
potassium (40)
potassium iodide
potassium salt
potentiometer

primate

promethium
propane
propellent
prophylactic

protein
proton
pulmonary
pumice
purine

pyrogens
pyrotechnic

quartz

rad (365 - radiation)
radar
radiation
radioactive
radiologist

radiometer
radio telescope
radium
raman effect
reaction

reactor (atomic)
recessive gene
reciprocating
"Red Planet"
refraction

reproduction (plant - animal)
resonance
reticular formation
retina
retinoblastoma

revolution
Rh (positive and negative)
rhenium (187)
rhipidistian
ribonuclease

ribonucleic acid (RNA)
ribosomes
roentgen
rotation
rubidium

salmonella
sandstone
satellite
saturated fat
scintillation

sclerosis
secondary radiation
sedimentary
seismic
selective breeding

semiconductor
serotonin
serology
serum
shockwave

silica
silicate
silicone (rubber)
silver iodide
slate (Geol.)

slime mold
soapstone
sodium fluoride
sodium salt
sodium vapor

solar cell
solar flare
somascope
sonar
sonic

spectrum
spectrograph
spectroscope
speleology
sperm

spermatozoa
spermidine
spleen
spore (Biol.)
stapes

staphylococcus
stannous fluoride
stellar evolution
steroid
stethoscope

strain

stratoscope
stratosphere
streptococcus
streptomyces

stress
strontium (90 - 89)
succulents (Biol.)
sulfonylurea
sulfur

sulfur dioxide
sunspot
superconducting
supernova
suture

synchotron
synthesize
systolic

tandem
technicium
teflon
telemetry
telescope

tetracycline
thalidomide
theory
therapeutic
thermoelectric

thermoionic
thermonuclear
thermostat

thesis
thrombophletitis

thymus gland
thyroid gland
thyroxine
tin
torque

toxicology
trachoma
transistor
trauma
trichinosis

tritium
tumor
tungsten
turbine
tympanic membrane

ultrahigh frequency
ultrasonic
ultraviolet
ungent
universe

uranium
uranium oxide
urea
uremic
uterus

vaccination
vaccine

vacuum
vacuum tube
valine

Van Allen belts
vapor
vena cava
ventricle
Venus

vertebrate
vestigial
viable
vibrations per second
virologist

virus
vitamine
volt

watt
wave (Physics)
wavelength
wusite

xenon
X-ray

yttrium (90)

zinc
zirconium

PRINCIPLES NEEDED FOR INTERPRETING AND UNDERSTANDING SCIENCE-ORIENTED ARTICLES

Biological Sciences

Energy, Matter, and Life

1. The energy that makes possible the activity of most living things comes at first from the sun and is secured by the organism through the oxidation of food within its body.

2. Energy changes accompany all chemical changes in living organisms and every chemical change has physical concomitants.

Protoplasm and Cells

3. The distinctive properties of organisms depend upon the complexity of the molecular organization of protoplasm, the one essential constituent of every living thing.

4. Every cell consists essentially of a mass of protoplasm that is usually differentiated into a central portion, the nucleus, and an outer portion, the cytoplasm.

5. The nucleus of a cell always contains a complex of protein materials, chromatin, the specialized vehicle that transmits hereditary characteristics in organisms.

Life Processes

6. Many of the processes of change in the universe are rhythmic, or periodic, and life processes constitute no exception to the rule.

7. The fundamental life processes are the same in all organisms.

8. All chemical processes that belong to life itself are processes that occur in solution.

9. The colloidal nature of the cell material as a whole furnishes the basis of some of the fundamental life processes.

10. Throughout the life of every organism there is a building up and a tearing down of protoplasm with constant transformations of energy.

Metabolism

11. The protoplasm of a cell carries on continuously all the general processes of any living body; the processes concerned in the growth and repair or upbuilding of protoplasm (anabolism) and the processes concerned with the breaking down of protoplasm and elimination of wastes from the cell (catabolism). The sum of all these chemical and physical processes is metabolism.

12. Diffusion, the spread of fluids and their dissolved substances, throughout the protoplasm of a cell or the tissues of an organism is an important method of conveying oxygen from the surface of a cell to the interior, or digested foods from the place of digestion to the protoplasm that will use them, or substances that stimulate any activity to the organ that responds to them, or the waste materials from the place where they are formed to the place where they are stored or excreted.

13. Osmosis, the diffusion of molecules of a solvent (usually water) through a semi-permeable membrane (a layer of cells or the membrane of a single cell) from the point of higher concentration of the solvent to a point of lower concentration, with a stoppage of the flow of molecules of the solute, is a basic process in plant and animal physiology.

Characteristics of Living Things

14. At every stage of development the individual is an integrated organism; all

of its cells, tissues, and organs are correlated and act together as a unit.

Material for Growth and Replacement

15. Digestion accomplishes two things: it makes food soluble in water, thus enabling the nutrients to pass through membranes and thereby reach and enter the cells; it reduces complex nutrients (fats, proteins, and carbohydrates) to simple building materials which in turn can be rebuilt into whatever living material or structural feature is necessary at the place of use.

Internal Transportation

16. Circulation is carried on in all living organisms. With increase in size and complexity of the body of an organism there goes a corresponding elaboration of the transportation (circulatory) system.

Integration of Activities

17. All living things respond to stimuli in their environment.

18. The nature of the response made by a cell to a stimulus is determined by the nature of the responding protoplasm, as well as by the kind of stimulus.

19. In general, the extent of a response is rather definitely fixed for any given nerve cell. If a cell responds at all, it does so to its full capacity.

20. From the simple to the complex organisms there is an increasingly elaborate coordination of receptivity of stimuli and response to stimuli.

21. The multitude of interrelated neurons of the nervous system of higher animals forms a complex system through which every organ of the body is in connection with every other organ.

22. Every animal comes into the world with a certain inherited endowment of congenital behavior.

23. Inherent reactions in animals are unlearned, independent of intelligence, and more or less inflexible in their operation; under natural conditions they are usually beneficial to the individual or the race.

24. Much of the behavior of living animals depends on their nervous organization, and they exhibit a great variety of behavior because the nervous organization varies in complexity.

25. The secretions of the endocrine glands are absorbed directly into the blood stream from the gland tissue that produces them and are absorbed from the blood by the tissues of the organs whose activities are regulated by these substances.

26. In animals certain waste products as well as vitamin and endocrine substances exert regulatory effects on the activities of various organs in the body.

Reproduction

27. Reproduction is a fundamental biological process that provides for the continuance of life on the earth by providing new individuals.

28. The ability and necessity of members of a species to produce other individuals like themselves is essential for the welfare and maintenance of the species, since no living thing can maintain itself for an unlimited period of time.

29. Sexual reproduction is an almost universal method of reproduction and occurs in representatives of every phylum of plants and animals.

30. All sexually reproduced individuals begin their careers as single fertilized cells.

31. In sexual reproduction a male cell from one parent unites with a female cell from the other parent to produce the young (except in the few cases of self-fertilization).

32. Throughout the plant and animal kingdoms there is a general preference for cross-fertilization; an avoidance of the union of eggs with male elements from the same individual. In those animals and in the great majority of plants which are hermaphrodite, there are usually precautions to restrain self-fertilization.

33. In organisms which reproduce by sexual means, fertilization serves two functions: stimulating the egg to develop, and introducing the hereditary properties of the male parent.

34. Sexual union in plants and animals affords a method of variation due to the combining of the egg and sperm, with their chromosomes and genes, at the time of fertilization.

35. In many organisms the number of young which are produced bears a definite relation to the chance of survival; the smaller the chance the more numerous the offspring.

Embryonic Development

36. Similarities in the embryological development of organisms show hereditary relationships between these organisms and the closer two species are related the longer they parallel one another in development.

Genetics and Heredity

37. The germ plasm of animals and plants passes on from generation to generation and there has been a continuous stream from the first organism to the present living organisms.

Chromosomes

38. Each kind of living thing has its characteristic chromosome complement, and the constancy of that complement is preserved at each cell division. Different species show the utmost diversity in number, size, and form of chromosomes.

Genes

39. The hereditary characteristics possessed by any organism depend wholly upon the genes that were transmitted to it in the reproductive cells received from its parents.

40. The hereditary characteristics in all organisms are determined by the genes which are carried in the chromosomes.

41. Genes that lie in the same chromosome tend to remain together in reduction division so that the characteristics which they determine are linked in inheritance.

42. The sex chromosome may carry the genes for a number of characteristics other than sex. Such characteristics are sex linked.

Mendel's Laws

43. Sex is inherited; it follows a given distribution of the chromosomes according to definite Mendelian ratios.

44. Acquired characteristics are not inherited.

45. Inbreeding in animals or plants results in a uniform strain.

Modification of Species

46. The evolution of the earth and the living things inhabiting it has resulted from the operation of natural forces.

47. Living things alter their types; present species have not always existed, but have originated by descent from others which in turn were derived from still earlier ones, and so down to the first living forms.

48. The forms of living things have changed slowly but steadily in the past except for those resulting from mutations.

49. Evolution has needed enormous lapses of time for its operations.

50. The crises of evolution when they occur are not crises of variation but of selection and elimination; not strange births but selective massacres. The germ plasm has gone on throwing up mutations at about the same rate age after age.

Mutations

51. The genes of all organisms are subject to change, such changes producing heritable modifications in organisms called mutations.

52. The history of organisms shows that evolution and race divergence has been the result of mutations.

53. All heritable variations which are not the result of recombinations of genes are mutations, which are changes in genes, in some cases induced by environmental agents.

54. New kinds of living things have arisen through mutation.

55. Any hereditary change that follows the laws of Mendelian heredity is due to a gene mutation.

56. Mutations occur independently of the activities of individuals as more or less haphazard hereditary variations.

Adaptations

57. All living things are slowly changing, both structurally and functionally, in response to changes in their physical environments.

58. The chief difference in the structure of organisms from the lowest to the highest are resultant of the means adopted to perform certain functions under different exigencies imposed by the environment and mode of life.

59. Those organisms which cannot adjust themselves to their environment lose out in the struggle for existence.

ECOLOGICAL RELATIONSHIPS

Environment and Living Things

60. The environment acts upon living things, and living things act upon their environment.

61. All living things are continually engaged in an exacting struggle with their environments.

Limiting Factors

62. The numbers of any species depend, on the one hand, upon its rate of reproduction and growth, and on the other, upon its death rate from accident, enemies, and disease.

Interdependence

63. Every living species is continually producing a multitude of individuals, many more than can survive, varying more or less among themselves, and all competing against each other for the available energy.

64. A balance in nature is maintained through interrelations of plants and animals with each other and with their physical environment.

GEOGRAPHIC DISTRIBUTION

65. Living things are not distributed uniformly or at random over the surfaces of the earth, but are found in definite zones and local regions where conditions are favorable to their survival.

66. Life exists from the depths of the ocean to the mountain heights.

67. Each species of animal or plant tends to extend its range until some

impossible barrier is encountered.

68. Discontinuous widespread distribution is characteristic of old groups of animals and means that they formerly occupied also much of the intervening space.

69. For most species of organisms, periods of great scarcity of individuals alternate with waves of great abundance, and the peaks of the waves succeed each other in a regular cycle.

70. New species of plants and animals appear at some definite point on the earth and then spread out from that location as a center.

PALEONTOLOGY

Fossils

71. Fossils, dated by the rocks in which they are found, reveal portions of the actual story of life's past changes by a progression of forms from simple to complex.

72. Organisms whose fossils are found in any quantity lived and died in the period when the strata in which their remains are found were laid down.

73. In fossilization, it is usually the hard parts of organisms that are preserved.

APPLIED BIOLOGY

Diseases

74. For most species of organisms the great checks on increase in numbers are enemies, disease, and competition between individuals of the same species and of one species with another for food and other necessities of life.

75. Most cases of fermentation, souring, and putrefaction are brought about by living micro-organisms.

76. Certain one-celled organisms escape adverse conditions by forming highly resistant spores which often survive until conditions are again favorable.

Chemistry

Structure and Characteristics of Matter

1. A pure chemical substance may be prepared from raw materials through utilization of their physical and chemical properties.

2. All substances are made up of small particles called molecules, which in turn are composed of atoms and are alike (except for variations in weight due to atomic isotopes) in the same substance but differ in different substances.

3. Atoms of all elements are made up of protons, neutrons, and electrons (and) other particles) and differences in the various elements are due to the number of protons and neutrons in the nucleus and the number and configuration of the electrons surrounding the nucleus.

4. Certain atoms undergo various degrees of nuclear disintegration, emitting various particles and energy, and producing different elements.

5. Each element has a characteristic X-ray spectrum; and when heated to incandescence in the gaseous state, has a characteristic glow and spectrum which can be used to identify the element and which is related to the molecular and atomic structure of the gas.

6. Physical states of matter are determined by the quantity of energy possessed by its molecules.

Behavior of Matter

7. Most atoms have the property of losing, gaining, or sharing a number of outer electrons.

8. No chemical change occurs without an accompanying energy change.

9. Molecules are in a constant state of motion.

10. The speed of chemical reactions is increased by increasing the concentration of any of the reactants; and is decreased by decreasing the concentration of any of the reactants.

11. The properties of alloys are dependent upon the relative amounts of their components, the extent of their compound formation, and upon the crystalline structure of the mixture.

Ions and Solutions

12. The constituents of a solution are homogeneously distributed through each other.

13. Electrolytes dissolved in water or in a molten state exist partially or completely as electrically charged particles called ions.

14. Electrolytes are decomposed during electrolysis in an amount that depends on the total quantity of electricity used.

Carbon Chemistry

15. Carbon atoms form a number of "type-groups" of compounds which are determined by the elements present and by the structural combinations of the atoms within the molecules.

16. Elements and compounds to which the cells of living organisms react specifically produce physiological effects.

17. The enzymes, vitamines, and hormones are chemical regulators of the reactions that occur in living organisms.

Geology

Diastrophism and Vulcanism

1. Earthquakes are produced by the sudden slipping of earth materials along faults.
2. Igneous rock may be formed from materials intruded into other rocks.
3. Rocks may be formed by the cooling and solidifying of molten material.
4. Rocks may be formed by the compacting and cementing of sediments.
5. Rocks may be metamorphosed, or changed, by heat, pressure, and flexion.

Degradation

6. Parent material for the development of soils is formed through the physical disintegration and chemical decomposition of rock particles and organic matter.

Physics

Mechanics

1. Energy can be changed from one form to another, or to matter, with exact equivalence.
2. Any two bodies attract one another with a force that is directly proportional to the attracting masses and inversely proportional to the square of the distance between their centers of mass.
3. Movements of all bodies in the solar system are due to gravitational attraction and inertia.
4. Bodies in rotation tend to fly out in a straight line that is tangent to the arc of rotation.
5. The energy that a body possesses on account of its motion is called kinetic energy and is proportional to its mass and the square of its velocity.
6. When pressure is applied to any area of a liquid in a closed container, it is transmitted in exactly the same intensity to every area of the container in contact with the liquid.
7. As the velocity of flow through a constricted area increases, the pressure diminishes.
8. In the northern hemisphere great volumes of air revolve in a counterclockwise direction, and in the southern hemisphere, they revolve in a clockwise direction.

9. In moving air, wind pressure increases as the square of the velocity.

10. The atmospheric pressure decreases as the altitude increases.

11. The atmospheric pressure decreases with increasing water vapor content, other things being equal.

12. The earth is protected partially from damage by meteors and electromagnetic radiations of short wave lengths due to the existence of the atmosphere.

Universe and Solar System

13. The rotation of the earth from west to east on its axis causes day and night.

14. The force of gravity pulls objects toward the earth.

15. The sun's gravity holds the earth and other planets in their orbits around it.

16. The sun is the source of almost all of the available energy on the earth.

17. Most stars are hot and glow with their own light.

18. The length of the day and the angle at which the rays of the sun hit the earth determine the amount of heat received by the earth and give us our seasons.

19. When the light of the sun is cut off either by the earth or moon, there is an eclipse.

20. The more dense a body the greater is the pull of gravity on that body.

21. Every planet has two motions, rotation and revolution.

Heat

22. The principal cause of wind and weather changes is the unequal heating of different portions of the earth's surface by the sun; thus all winds are convection currents caused by unequal heating of different portions of the earth's atmosphere, and they blow from places of high atmospheric pressure to places of low atmospheric pressure.

23. Heat is transferred by conduction through solids, liquids, and gases; by convection through liquids and gases; and by radiation which travels in photons through space.

24. Heat is conducted by the transfer of kinetic energy from molecule to molecule.

25. When two bodies of different temperature are in contact, there is a continuous transference of heat energy, the rate of which is directly proportional to the difference of temperature.

26. The lower the temperature of a body, the less the amount of energy it

radiates; the higher the temperature, the greater is the amount of energy radiated.

27. Dark, rough, or unpolished surfaces absorb or radiate energy more effectively than light, smooth, or polished surfaces.

28. Condensation will occur when a vapor is at its saturation point if centers of condensation are available and if heat is withdrawn.

29. The higher the temperature of the air, the greater the amount of moisture required to saturate it.

Light

30. Light waves travel in straight lines while passing through a homogeneous or uniform medium, and consist of photons of energy.

31. The speed of light in any given substance bears a constant ratio to the speed of light in air.

32. When parallel light strikes a concave spherical mirror, the rays, after reflection, pass directly through the principal focus only if the area of the mirror is small compared to its radius of curvature.

33. The dispersion of white light into a spectrum by a prism is caused by unequal refraction of the different wave lengths of light.

34. When white light passes through a substance that absorbs some waves and not others, certain bands of color are missing with the production of an absorption spectrum.

35. Luminous vapors and gases emit only certain kinds of light producing bright-line spectra.

36. A beam of light may become plane polarized as the result of any circumstance that results in the suppression of one of the rectilinear components of the vibration without affecting the components at right angles to it.

37. The color of light is determined by the energy of the photons. Red photons have low energy. Blue photons have higher energy.

38. The speed of light varies with the density of the medium through which it travels.

39. Light does not depend upon a medium for transmission.

40. When waves strike an object, they may either be absorbed, transmitted, or reflected.

41. The darker the color of a surface, the better it absorbs light.

42. If a beam of light falls upon an irregular surface, the rays of light are scattered in all directions.

43. The colors of objects depend upon what light rays they transmit, absorb, or reflect.

Sound

44. Animals possess varying degrees of sensitivity to frequencies of sound waves.

45. Sound is produced by vibrating matter and is transmitted by matter.

46. When energy is transmitted in waves, the medium which transmits the wave motion does not move along with the wave, but the energy does.

47. The velocity of sound is directly proportional to the square root of the elasticity modulus and inversely proportional to the square root of the density of the transmitting medium.

48. The speed of sound increases with an increase in temperature of the medium conducting it.

49. Sound waves are reflected in a direction such that the angle of incidence is equal to the angle of reflection.

50. Sound waves or other energy impulses may set up vibrations in a body the amplitude of which is increased if the impulses are exactly timed to correspond to any one of the natural periods of vibration of the body.

51. The higher the pitch of a note, the more rapid the vibrations of the producing body.

Electricity and Magnetism

52. Charges on a conductor tend to stay on the surface and to be greatest on the sharp edges and points.

53. Electrons have both a magnetic and an electric field.

54. In an uncharged body there are as many protons as electrons and the charges neutralize each other; while a deficiency of electrons produces a plus charge on a body and an excess of electrons produces a negative charge.

55. Positively charged ions of metals may be deposited on the cathodes, as atoms, when a direct current is sent through an electrolyte.

56. The mass of any substance set free by electrolysis is proportional to the current flowing and the time of flow, if the quantity of electricity is kept constant the masses of the various substances set free are proportional to their electro-chemical equivalents.

57. Whenever a high-frequency oscillating current produces in the field around it oscillating electric and magnetic fields, energy in the form of an electro-magnetic wave is transmitted through space.

58. An electric current may be produced by cutting magnetic lines of force and by chemical action.

59. Electrons will always flow from one point to another along a conductor if this transfer releases energy.

60. An electrical charge in motion produces a magnetic field about the conductor, its direction being tangential to any circle drawn about the conductor in a plane perpendicular to it.

61. Many objects collect static electricity through friction.

62. Like electrical charges repel; unlike charges attract.

63. A magnet always has two poles and is surrounded by a field of force.

64. Like magnetic poles always repel each other and unlike magnetic poles always attract each other.

Atomic Energy and Radiations

65. Electrons are emitted from any sufficiently hot body.

66. Electrons change energy levels emitting or absorbing energy.

67. When a stream of high speed electrons strikes a body, the atoms of that body emit X-rays.

68. Radioactive emission involves nuclear changes.

69. Radioactivity is independent of all physical conditions: heat, cold, pressure, and chemical state.

70. Matter may be transformed into energy and energy into matter, the sum total, matter plus energy, remains constant.

71. Elements may be changed into other elements.

72. Atoms have great subatomic energy.

73. Some elements have more than one atomic weight due to differences in the neutron content of their nuclei.

74. Atoms may be broken down by bombarding the nucleus with high speed particles such as protons, alpha particles, and neutrons.

75. Atoms or molecules may lose electrons when struck by high speed electrons or ions.

76. The atoms of all radioactive elements are constantly disintegrating by giving off various rays (alpha, beta, and gamma) and forming helium and other elements.

A breakdown of the principles into various science areas shows that 76 were associated with life sciences, 76 with physics, 17 with chemistry, and six were related to geology. Principles of astronomy and meteorology were included with physics.

SOME IMPLICATIONS

An analysis of the findings presented in this report provides answers or partial answers to the four questions posed on page 3. For instance, what does a person need to know in order to be scientifically literate in this aerospace age, and can a science education program in the public schools provide young people and adults with the knowledge essential for scientific literacy? If so, what science topics should be included in the several required courses?

The compiled lists of vocabulary words and principles give some guidelines that should prove useful in identifying a number of basic science concepts and generalizations for inclusion in science curriculums. Certain ones could fit readily into the general science programs of the elementary and junior high schools; whereas, others would be suited for high school biology, chemistry, physics, and some of the newer courses. A logical sequence of subject matter and open-ended demonstrations and experiments thus developed could provide the student with a working knowledge of many if not most of the scientific principles and vocabulary words identified in this study. It is, therefore, the belief of the investigators that the public schools can be a major agency in helping produce a scientifically literate citizenry, and that the lists constitute desirable subject matter for scientific literacy.

As for the fourth question, do the new science courses that were developed by the nationally-financed curriculum projects furnish basic subject matter essential for scientific literacy, the following quotations taken from (6) provide information on chemistry:

> Analysis of the occurrence of the 286 chemistry words and terms in the vocabulary list...revealed that 238 or 81.8 per cent were found in the contemporary traditional texts...and 199 or 69.7 per cent in the new curriculum texts....With the exception of a few terms generally used in a more detailed study of atomic and molecular structure found only in the new curriculum texts, other words and terms were more likely to be found in the traditional texts.

> Comprehensive reading and understanding of the newspaper and magazine science articles required 17...of the principles listed. Two-thirds of these dealt with characteristics, structure, and behavior of matter and one-third was equally divided between ions and solutions and carbon chemistry. All of these principles were found in each of the texts reviewed.
>
> In summary, although principles appeared equally in the traditional and new curriculum texts, words and terms found in science articles from popular literature were contained to a greater extent in the traditional texts.

Similar studies would have to be completed in the fields of biology and physics before a reliable answer relative to these areas could be compiled.

Government-sponsored projects such as those associated with space exploration and research in the field of public health influenced greatly the frequency and science areas of articles noted in the newspapers and magazines. A number of these were compiled obviously for their news appeal rather than providing the reader with scientific information essential for understanding "how" and "why."

Some errors were noted in the discussion of certain scientific phenomena. Three illustrations of this are: (a) "New Element Found Lethal" and then a story of NO_2 in smog was presented; (b) "The same side of Mercury always faces the sun because of her lack of rotation about her axis;" and (c) "Argon is so inert it combines with nothing." It was estimated that the number of such errors noted occurred in less than one per cent of the science articles.

What constitutes a working definition of scientific literacy? According to Webster in the Third New International Unabridged Dictionary, a literate individual is an educated person: one who can read and write. Further, literacy is the quality or state of being literate: an ability to read a short simple passage and answer questions about it. Lastly, scientific is concerned with or treating of science: devoted to the study or practice of science. By considering the findings in this study and the statements presented above, the following definition of scientific literacy seems adequate: scientific literacy

is a level of science education achieved by people when their backgrounds in science are such that they can understand, interpret, and interrelate scientific phenomena with facility, and form relevant and independent conclusions from information acquired through the media of mass communication.

What role do we as college professors of science and science education and elementary and secondary school teachers have in this scientific literacy problem? There seem to be three areas in which we all can exercise some influence.

1. Use the inquiry and process technique of scientists in teaching. This procedure enables students to do some thinking for themselves instead of memorizing specific information provided by their teachers and texts. "How" and "Why" become more important than "What."

2. Work continuously on science curriculum revision - at all levels - so the several courses will contain up-to-date procedures, principles, vocabularies, and scientific information needed for literacy.

3. Use the "best" from traditional and new science courses rather than throwing out one for the other. The important thing is that students be exposed to subject matter and laboratory experiences that challenge their capabilities and help them develop techniques of observing, recording, analyzing, interpreting, and forming conclusions based upon their own analyses. They then become thinkers instead of memorizers and conformists. Teachers become guides and resource persons instead of authorities with all of the answers.

Science education programs based on these considerations should provide experiences and subject matter essential for scientific literacy in any given era of time.

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APPENDIX A

NEWSPAPERS

Arizona Republic (Phoenix, Arizona)

Arkansas Gazette (Little Rock, Arkansas)

Atlanta Journal (Atlanta, Georgia)

Boston Record-American (Boston, Massachusetts)

Chicago Tribune (Chicago, Illinois)

Denver Post (Denver, Colorado)

Helena Independent Record (Helena, Montana)

Kansas City Star (Kansas City, Kansas)

Kansas City Times (Kansas City, Kansas)

Los Angeles Times (Los Angeles, California)

Minnesota Star (Minneapolis, Minnesota)

Montgomery Advertiser (Montgomery, Alabama)

New Orleans Times-Picayune (New Orleans, Louisiana)

New York News (New York, New York)

Pittsburgh Press (Pittsburgh, Pennsylvania)

Portland Oregonian (Portland, Oregon)

Raleigh News and Observer (Raleigh, North Carolina)

Salt Lake Tribune (Salt Lake City, Utah)

St. Petersburg Times (St. Petersburg, Florida)

The Tennessean (Nashville, Tennessee)

The Toledo Blade (Toledo, Ohio)

Washington Post (Washington, D. C.)

APPENDIX B

MAGAZINES

Better Homes and Gardens

Family Circle and Woman's Day

Ladies' Home Journal

Life

Look

McCalls

Reader's Digest

Saturday Evening Post

Time

Death' of Compu... to Aid Heart Study

RONALD KOTULAK
...onic computer soon ... on Northwest... Chicago cam... ...fume, ... and ...

TRIBUNE Staff Ph...

Savants Seek Vaccine For Tooth Decay

WASHINGTON ...
sur... on of ...
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22 Part I—MON., DEC. 17, 1962 Los Angeles Times 2★

17th Street ...

Helium Now Being Saved

By Robert Murray

helium salvaged from natural ... underground ...

Chicago Tribune TUESDAY, FEBRUARY 19, 1963

Psychologi... Tests Phony... Observer S...

THERA...
Operating Und...
The high pressur... divers and tunnel ... has always been ...

Mariner 2 Will Orbit Sun Every 345 Days

Venus Probe Satellite's Circuit ...
From 65 to 113 Mi...

Los Angeles Times 2★

6 Part I—WED., MAR. 6, 1963

Jet Lab Finds Method for Sterilizing Rockets

Ingredient in Propellant Will Prevent Earthly Contamination of Other Planets

...ERVIN MILES, Times Aerospace Editor

Propulsion de... posited on the plane... ...eloped to start the spread of con... solid... ation.

Montgomery, w... ...d development c... ...ion process ... was ...

26 Part I—THURS., APR. 18, 1963 Los Angeles Times 2★

Zone of Storms Found in Atmosphere of Venus

BY GEORGE GETZE, Times Science Writer

A great "zone of storms" upper atmosphe... exists in the atmosphere of ... is about 75 ... Venus, Bruce Murray, re... below ... search fellow in space sci... ...ree... ce at Caltech, reporte... dnesday.

Murray said a h... fitted to ... on ...

The Atlanta Journal and CONSTITUTION

8

RADIATION TEST

'Synthetic Man' To Explore Space

By THOMAS R. HENRY
North American Newspaper Alliance

WASHINGTON, Jan. 19—Newest American "air-man" is the plastinaut.

...w man made of ... bly very dangerous ionization ra... diation from several sources.

Atom Fuel Held Boon to Ma...

...ill Help to Solve ...orld Problems

...Y RONALD KOTULAK

... atomic fuel created by ... will help solve such prob... as population overcrowd... the plight of underdevel... nations, dwindling sources ...ural fuel, and space ex... ...on, the chairman of the ... Energy commission ...sterday.

...T ...berg, co-discov... ...f... the ...

6-B The Arizona Republic

...llan (left) of University of California and ...ergy commission chairman, at ...versity of Chicago

Phoenix, Sunday, Jan. ...

Profiles In Science

By Patrick And Getze

Max Planck was born at Kiel, Germany, in 1858. He was a diligent and brilliant student from his first day in school and received his doctor of philosophy degree from the University of Berlin when he was only 21.

Planck studied physics and mathematics at Berlin. He was lucky to have among his teachers Herman von Helmholtz, ...nator of the ophthal... Gustav Kirchhoff, ... the spectroscope, ...mous students of ...

...ting his degree, ...e an assistant pro... ...l. In 1889 he suc... ...loff as professor of ...rlin.

...hief interest in thermodynamics, ...f heat and en...

...d the way ...given off ...l ways ...r. But ...rtain ... in ...

14 The Arizona Republic

Osmosis Process H... Of Cheaper Sea W...

MAX PLA...

...had to assume that since this ... ...ory was untrue, the ... ...be true, ...ue, ...

By GEORGE GETZE ... Service

...symposium ...version at ...meeting o...

CHICAGO TRIBUNE, SUNDAY, MARCH 17, 1963

American Sun Satellite of Six Months Ranks as

Orbiting Lookout Still Returns Vital Data

BY RONALD KOTULAK

...United States' most suc... which affect conditions on earth, the pattern and intensity of solar flares that could cre... ...inate space travelers, and the Van Allen radiation belt.

Seek Atmosphere Data

It is hoped that data gathered by the satellite will answer ... ...ments of the sun's radiant ... has surpassed all goals set by the National Aeronautics and Space administration and it is paving the way for NASA's manned moon flight, expected before the end of this decade.

The satellite's focusing device has kept the instruments locked on the sun's center, ... ellite is over a ground receiving station.

Passage thru the artificial radiation belt created by the high altitude nuclear blast in the Pacific last July has handicapped the use of the solar cells used to power the spacecraft. The satellite is in a 350 ... high, nearly circular, or... ...forms an artificial atmo... on the surface of the ... ...nents, enabling them to ... under ground conditions.

Eleven of the satell... complex scientific com... are still functioning a... ...cent back more data on ...havior and composition ...om than any single ...